Chapter XVIII

THE ZEISS CONTACT LENS PROTOTYPES

Introduction

In 1916, *Siegrist* showed the superiority of blown contact-shells over the hydrodiascope for the correction of keratoconus. (1) Soon, however, it became apparent that these scleral contact lenses (2) were less than perfect, due to the fact that they were of blown glass. It was also evident that, in the future, technical progress would allow the production of contact lenses equipped with a ground optic, thus providing satisfactory patient comfort and an easy and logical fit. The demand for this was strong because there was no satisfactory optical, medical, or surgical alternative for the management of patients with keratoconus.

Bi-curved ground scleral contact lenses had already previously been used in 1888 by *August Müller* for the correction of his own myopia (3). In the years that followed, *Sulzer, Dor, Fick,* and *Kalt* also had them manufactured (4).

The quality of the glass and the manufacturing methods did not permit the production of devices that were adequate and the hopes placed on this method for correction were quickly disappointed. Meanwhile, the *Zeiss* firm had been using single-curved ground contact lenses of corneal diameter for their experiments in physiological optics. The bi-curved grinding, starting from a single block of glass, was, however, running into major technical difficulties.

This chapter recounts the chronology of the development and trials of scleral contact lens prototypes in glass and celluloid, ground or molded specifically for the correction of keratoconus between 1914 and 1920.

Year	***Author***	***Title***
1914	*Bielschowsky (Marburg)*	*"Geschliffene Glasprothesen" (Ground Glass Prostheses)*
1916	*Weill (Strasbourg)*	*"Ueber Korrektion des Keratokonus durch Prothesen" (Concerning the Correction of Keratoconus by Prostheses)*
1916	*Erggelet (Jena)*	*"Zur Korrektion des Keratokonus" (On the Correction of Keratoconus)*
1918	*Wigand & Hippel (Halle a.S.)*	*"Verfahren zur Herstellung von Kontaktbrillen" (Procedure for the Manufacture of Contact Lenses)*
1920	*Stock (Jena)*	*"Über Korrektion des Keratokonus durch verbesserte geschliffene Kontaktgläser" (Concerning the Correction of Keratoconus by Improved Ground Contact Lenses)*

Table 18 - 1
Chronology of some publications on non-commercialized ground contact lenses

1 - Source Documents

1.1 – The experiments with Ground-glass Contact Lens Prototypes

Starting in 1912, physicians at the University Eye Clinic in Jena, namely *Stock, Erggelet,* and *Ishihara,* as well as *von Mohr,* who was the engineer for the *Zeiss* firm, used ground contact lenses in order to create refractive errors by artificial means for the study of physiological optics and to research the correction of anisometropia spectacle glasses. (5) The tolerance for these ground monocurved contact lenses of corneal diameter was limited to about the thirty minutes required for the experiments. In 1913, *Helmbold* was the first to present the first publication describing the fitting of keratoconus with blown contact-shells in a publication expressing the hope that this experiment might provide momentum for the manufacture of ground models. Elsewhere, he had announced, incorrectly, that *Zeiss* had ground the optical zone of blown contact-shells in order to give them appropriate refractive power. (6)

From time to time, one or two prototypes of contact lenses that had been ground for experiments in physiological optics, were forwarded to physicians selected for their interest in the correction of keratoconus. Three sites are described in the literature: Marburg (*Bielschowsky*), Strasbourg (*Weill*), and Jena (*Erggelet*). It is possible that other clinics were also chosen, but no evidence of them has been discovered.
During the same epoch, *Wigand* and *Von Hippel* carried out other experiments in Halle, using prototypes of celluloid contact lenses with ground optics.

1.1.1 – The Marburg Experiments (Bielschowsky 1914)

In 1914, *Bielschowsky*, who was Director of the *University Eye Clinic in Marburg*, made reference to the intolerance that he had observed with **“***ground glass-prostheses”*, but he did not say who the manufacturer was: *“This 35-year-old woman has been wearing blown Müller* (*Wiesbaden*) *contact lenses for 1 ½ years without any problem.She did not tolerate ground glass prostheses.”* (7)
It is possible, although not proven, that the “ground glass prostheses” (geschliffene Glasprosthesen) referred to were contact lenses ground by *Zeiss* following the models used throughout these same years for experiments in physiological optics.

Figure 18-1
Weill's publication on ground contact lenses
In 1916, Georges Weill, Professor of Ophthalmology at the University of Strasbourg, describes in his publication "Ueber Korrektion des Keratokonus durch Prothesen" (Concerning the Correction of Keratoconus by Prostheses) that Zeiss had sent him two "ground contact glasses", one of which did not have a scleral zone.
(WEILL Georges "Ueber Korrektion des Keratokonus durch Prothesen", Klinische Monatsblätter für Augenheilkunde, 57, 1916, 126-128 - Excerpt of page 126)

1.1.2 – The Strasbourg Experiments (Weill 1916)

In 1916, *Weill*, who was Professor at the *University of Strasbourg*, reported that *Zeiss* had sent him two “ground contact glasses” that had arrived on his doorstep without his having ordered them and without any other information. He referred to this occurrence in his publication entitled ***"Ueber Korrektion des Keratokonus durch Prothesen"*** *(Concerning the Correction of Keratoconus by Prostheses)*. One of the contact lenses consisted of an optic zone only, while the other possessed a scleral rim:

"About nine months ago, the firm of Zeiss Jena, provided me with two of their contact glasses for experiments. One of these had a border, while the other did not. They had been manufactured without special orders from me but gave a better optical result than the Müller prostheses. Unfortunately, they were tolerated for only a short time, and I think this was because they rested solely on the cornea and not on the sclera, which is less sensitive. For this reason, I suggested to Zeiss that they provide their precisely ground contact glasses with a large border that would extend over the sclera or to solder them, so to speak, in Müller prostheses. The firm was not able to carry out these trials because it was "wartime", so they informed me." (8)

The trials of these contact lens prototypes in three patients with keratoconus were successful from a visual standpoint, but ocular irritation caused rapid discontinuation of their wear. The three patients were later fitted with blown *Müller* scleral shells:

"Case I […] Repeated trials with Zeiss contact glasses did not give any [satisfactory]result because of immediate severe inflammation.

Case II […] With the Zeiss contact glass without saline solution, visual acuity rose to 1/2, but it rapidly produced signs of irritation.

Case III […] With the Zeiss border-free contact glass and without adding aqueous [solution], visual acuity rose from 1/2 to 2/3. The patient was very pleased with this tremendous visual result, but was unfortunately able to tolerate the contact glasses for only a short while, as the eyes became rapidly irritated." (9)

It is very likely that, in light of these investigations, at least one of the contact lenses was of monocurvature and with the same diameter as the cornea. This is because of the type of contact lenses used in Jena for experiments in physiological optics during the same time-period. (10)

1.1.3 – The First Jena Experiments (Erggelet 1916)

In the same year (1916), *Erggelet*, who was then Professor of Ophthalmology in Jena, presented his observations on a high-school student with bilateral keratoconus who had been fit with *Zeiss* ground contact lenses with a small scleral component. His contribution was entitled ***"Zur Korrektion des Keratokonus - (Demonstration eines Falles)"*** *(On the Correction of Keratoconus – Demonstration of a Case)*. The case history makes the following points*:*

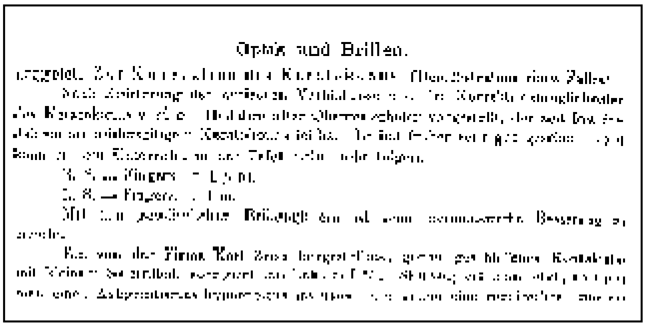

Optik und Brillen.

Figure 18-2
Erggelet's publication on ground contact lenses
In 1916, Professor of Ophthalmology in Jena Heinrich Erggelet presented a case study of a high-school student with bilateral keratoconus in a communication entitled "Zur Korrektion des Keratokonus - Demonstration eines Falles" (On the Correction of Keratoconus - A Case Presentation). He had used ground Zeiss contact lenses with a small scleral component.
(ERGGELET Heinrich, "Zur Korrektion des Keratokonus - Demonstration eines Falles", Klinische Monatsblätter für Augenheilkunde, 56, 1916, 624-625 - Excerpt of page 624)

"After recalling the optical conditions and the possibilities for the correction of keratoconus, he [Erggelet] presented a high-school student aged 16 years who has been suffering from keratoconus since he was three years of age. Although he had seen well previously, he could no longer follow the lessons on the blackboard. His visual acuity was "counting fingers" at 1.25 meters in the right eye and at 1 meters in the left eye. The usual eyeglasses do not produce

any significant improvement.
A contact glass that was manufactured by the Zeiss Firm, ground with precision and provided with a small scleral part, corrects the left eye to 5/7. […] By adding corrective lenses […], he had normal visual acuity in his left eye. The right eye achieves only 5/7 to 5/10 with the contact glass. This is because of mild clouding of the corneal apex." (11)

Erggelet explained to his audience that the insertion of the lens was performed by the patient himself and that the small curved lens, 0.50 mm thick, adhered by capillary attraction to the eye, the movements of which it followed spontaneously without displacement or falling out:

"The patient has taught himself how to insert the small glass on his cornea, after filling it in advance with some saline.
Because the lens is perfectly adapted to the curvatures of the anterior segment of the ocular globe, its lightness and its minimal thickness of 1/2 mm make it adhere fully to the cornea by capillary attraction. It does not displace itself, never falls out, and follows all the ocular movements." (12)

He recalled the optical disadvantages of spectacle lenses and the advantages of contact correction. However, he also made mention of the limits of prolonged contact of the lens with the eye:

"The contact glass, which was introduced by A.E. Fick in 1888, does not possess all these secondary effects, for it shifts itself with the eye, as if we are dealing with a transplanted cornea. It does not produce any modification of its optical effect when the eyes move in different directions of gaze with reference to the correction obtained in the primary position, in whatever direction the eye might be rotated.
"One can thus confirm that contact glasses represent in theory the ideal spectacle lens. In any event, it is regrettable that they cannot be used instead of our customary spectacles in ordinary errors of refraction. This is because of the practical inconvenience of the contact glass. Not every eye tolerates it, especially in the long term. This has already been the cause of failure in several experiments in patients afflicted with keratoconus, in spite of the good optical results they may have obtained." (13)

In the course of the last six months, the patient had worn contact lenses two or three times a week for three to four hours per day. *Erggelet* concluded that they were the ideal form of spectacle lens for patients, except that their tolerance for these lenses was unfortunately still limited. Contact lenses also had a therapeutic effect because they protected the cornea from pressure from the eyelids:

"The case presented does not tolerate the glass on a long-term basis. Once, he wore his contact lens for 48 hours without interruption. This was followed by pain due to epithelial corneal lesions, which did, however, regress without sequelae. In the course of the last six months, he wore the glass two or three times a week for a few hours from 9 in the morning to 1 p.m., or 4-5 hours in the afternoon, and thus attended school. In this way, it did not cause him any inconvenience. At the beginning, he noted a few moments of tearing. In the afternoon, when he had taken the lens out, the eye was always very comfortable.
When you see him from afar, you absolutely do not notice if he is wearing the glass or not. The enormous advantage of the almost total return of his vision, that allows him to complete his studies, is evident. But, quite aside from the corrective effect, the contact glass also perhaps possesses a certain therapeutic value, perhaps as a supportive dressing for protection against deforming pressure by the eyelids in the course of the day." (13)

These evidentiary documents coming out of three German-speaking sites showed that *Zeiss* had tried to apply the results of experiments in physiological optics to the correction of errors of refraction. The trials were destined to failure due to the intolerance of the contact lenses and to the pathological conditions selected. The lenses of small total diameter, high thickness, and elevated weight, from which the scleral component had been removed or which had small scleral zones, lacked stability and this would explain the failure of *Bielschowsky*'s and *Weill*'s cases. The case of *Erggelet* is an exceptionally favorable one, even for a young subject, in whom lacrimation is abundant as the case history indicates. The tolerance was nevertheless reduced to just a few hours a day. The same patient was presented again by *Erggelet* in 1930, when he was still wearing contact lenses, but they were not *Zeiss* lenses. He had abandoned them in favor of blown *Müller* shells. (14)

Subsequently, World War I had interrupted the trials, both for manufacture and for early clinical application. *Bielschowski* would not refer again to the case he presented. *Weill*, however, would describe the failure of the experiments with early ground *Zeiss* contact lenses about twelve years later.

1.1.4 – The Second Jena Experiment and Stock's Communication on Ground Contact Lenses for Keratoconus (1920)

The first rather confidential trials with ground contact lenses were disappointing. *Zeiss* profited from the respite that resulted from World War I and, in the immediate post-war period, carried out research in order to find a solution to the intolerance that he observed with the prototypes.

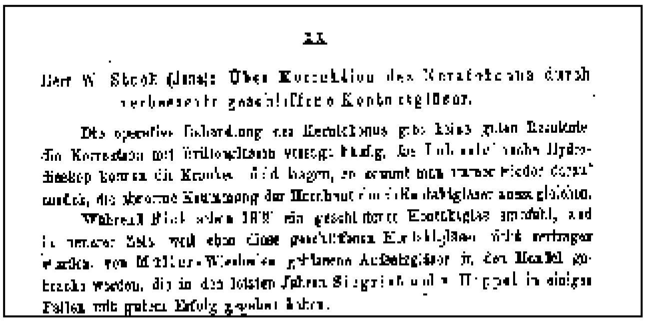

Herr W. Stock (Jena): Über Korrektion des Keratokonus durch verbesserte geschliffene Kontaktgläser.

Figure 18-3
Stock's publication on ground Zeiss contact lenses (1920).
In 1920, Wolfgang Stock, who was at that time the director of the Eye Clinic in Jena, gave a talk at the annual congress of the German Ophthalmological Society in Heidelberg with the title "Über Korrektion des Keratokonus durch verbesserte geschliffene Kontaktgläser" (The Correction of Keratoconus by Improved Ground Contact Lenses). This was the first communication to describe contact lenses ground by Zeiss for the correction of keratoconus.
(STOCK Wolfgang, Über Korrektion des Keratokonus durch verbesserte geschliffene Kontaktgläser" Bericht der Deutschen Ophthalmologischen Gesellschaft, 42, 1920, 352-354. - Excerpt of page 352) (See full text in Appendix 18 - 3)

In 1920, *Stock*, who was Director of the University Eye Clinic in Jena, presented a communication to the annual congress of the German Ophthalmological Society, entitled "***Über Korrektion des Keratokonus durch verbesserte geschliffene Kontaktgläser***" *(Correction of Keratoconus by Improved Ground Contact Lenses*). (15) This communication marked the official date of birth of ground *Zeiss* contact lenses suitable for the correction of keratoconus.

After the usual recapitulation of the difficulties of optical management of keratoconus by spectacle lenses, the failure of the hydrodiascopes, and the inadequate optical correction of the blown contact shells of *Müller* of Wiesbaden, *Stock* described the ground scleral contact lens, which he compared with blown contact shells:

"I would like to present to you a ground contact glass that patients can tolerate. Why are blown contact glasses better tolerated than ground ones are? In conjunction with Professor Henker we have tried to give an answer to this question. Müller claims that the surface of blown glass may be smoother than that of the ground and that this difference may be at the origin of the superior tolerance of blown [contact] glasses. The quality of the surface of a blown glass is certainly slightly different from that of a ground one. But the main reason for the intolerance of ground glasses relative to blown lies in the sharp edges of the ground glasses. All edges have to be well rounded. Not only the external edge, but also, above all, the internal transition between the scleral and corneal parts." (16)

Aside from the improvement of the transition between the optical and the scleral zones, the new models would also have an improved fit of scleral curvature. The corneal zone of the definitive contact lens could be ground in such a way that a liquid lens would be created to correct the myopia of 12 diopters that was induced by elongation of the optical system after placement of the contact lens on the eye:

"It is important that the curvature of the border part of the shell corresponds exactly to the curvature of the sclera and that the corneal part provides sufficient space within its back cavity. This last requirement is not always easy to achieve in keratoconus. It is necessary to measure accurately the proeminence of the cornea in relationship to the scleral border and to manufacture the shells accordingly.
Because of this great molding and changes of curvature around the front part of the eye, plus the effect of the contact glass, an elongation is produced and a myopia of about 12 diopters appears with shells having a central portion of usual curvature. A new glass, ground with a refraction of less 12 diopters, corrected the keratoconus and produced emmetropia." (16)

Then he goes on to say:

"The technical progress achieved allows today's manufacture of contact glasses to such a degree of perfection that they respond to all the requirements that we can ask of them:

1. The contact glass now consists of a scleral and a corneal part. The scleral part has to be sufficiently wide (about 6 mm) that even when looking up it cannot be caught by the lower lid margin.
2. At the same time, the external edge and particularly the transition between the scleral and the corneal parts has to be perfectly rounded in order not to provoke ocular irritation.
3. The corneal part must be ground for all desired powers." (16)

For *Stock*, the choice of the best contact lens was relatively complex because it demanded the appreciation of the forward projection of the summit of the cone in relationship with the limbal plane. An early contact lens was manufactured according to these requirements, then, if necessary, a residual optical correction would be added with spectacle glasses or by the manufacture of a new contact lens with a different back optic zone radius*:*

"The fit of such a contact glass would be made as follows: First of all, one measures the forward projection of the summit of the cornea in relation to the corneo-scleral border. Then you have a glass into which the cornea can fit. A residual refractive error can then be corrected by a spectacle lens or, better, by a new contact glass with sufficient correction.
Of course, the ophthalmologist could also purchase one or other contact glass. It would suffice, in this instance, to insert the contact glass, measure the refraction, and order the appropriate contact glass." (16)

Stock reports briefly the outcome of two recent fits: the first patient wore the contact lens for the whole day; the second patient experienced difficulties because of air bubbles that became interposed between his eye and the contact lens. In this patient, *Stock* noted a "reshaping effect" due to remodeling of the cone and improvement in vision, which he attributed to flattening of the cornea under pressure from the contact lens:

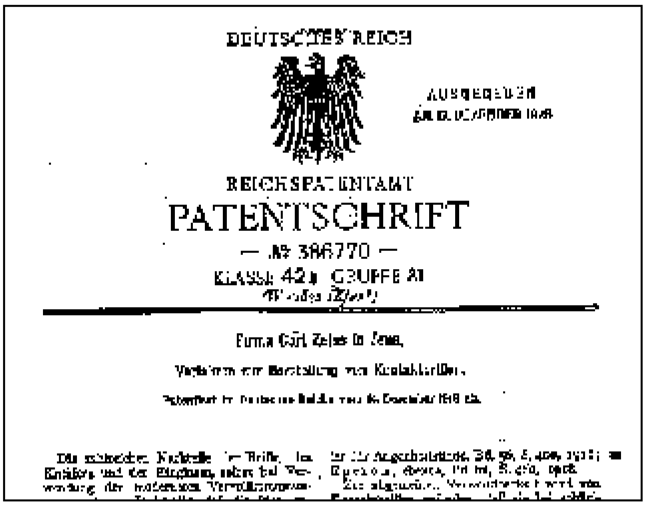
"One of the patients [a woman] wears the contact glass easily and for practically the whole day. The insertion does not cause her any difficulty. The visual acuity improves from 1/60 to 5/7.
In another case, insertion of the lens is difficult, for air bubbles always appear between the glass and the cornea. In this second patient, I noted the very curious observation that the visual acuity is better after the glass had been worn than before. Von Hippel had already made the same observation. I have not yet been able to verify whether a flattening of the cone occurred. If these lenses have a therapeutic effect in addition, there would be a double indication for using them." (17)

1.2 – The "Cellon" Experiments (Wigand, Hippel 1918-1923)

Date	
December 14, 1918	Deposition of the Patent Documents by Wigand
January 4, 1922	Surrender of Wigand's patent to Zeiss
June 3, 1922	Deposition for U.S. Patent by Wigand, assignator for Zeiss
June 5, 1923	Award of the U.S. patent
December 17, 1923	Award of the German patent
December 8-9, 1929	Clausen communication in Leipzig
1930	v.Hippel and Clausen communication in Heidelberg

Table 18 - 2
Time relationships of the first contact lenses to be ground from an organic material (Cellon).

During this period of history that was characterized by experiments with glass contact lenses, there occurred a remarkable episode, namely the manufacture of celluloid contact lenses by *Zeiss* and an experimental trial of them, which physicians of Halle carried out.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PATENTSCHRIFT

— № 386770 —

Firma Carl Zeiss in Jena.

Verfahren zur Herstellung von Kontaktbrillen.

Figure 18-4
German patent # 386.770
On December 17, 1923, the "Firm of Carl Zeiss in Jena" granted a German Patent entitled "Verfahren zur Herstellung von Kontaktbrillen" (Manufacturing Process for Contact Spectacles), the application for which had been applied for by Wigand on December 13, 1918.
(See full text in Appendix 18 - 1)

The firm *Carl Zeiss* Jena had acquired a German patent, "***Verfahren zur Herstellung von Kontaktbrillen***" *(Manufacturing Process for Contact Spectacles)*, which was applied for by the engineer *Wigand* on December 17, 1923. A similar patent was awarded to *Wigand*, "assignator" to the firm of *Carl Zeiss* on June 5, 1923, at the United States Patent Office, with the title "***Contact Bowl.***"

The *Zeiss* archives contain a significant exchange of correspondence on this subject, particularly for the years 1919 to 1923. (18) These documents indicate that, according to the contract of January 4, 1922, *Wigand* had renounced in favor of *Zeiss* his rights associated with his application for a patent that he had registered on December 14, 1918. (19) After the patent had been assigned to *Zeiss*, on December 17, 1923, *Wigand* devoted himself fully to the dissemination of his invention. He saw to the acquisition of the American patent and collaborated with *Henke* in the manufacture of these contact lenses. The clinical trials had been entrusted to the Halle Eye Clinic, of which his father-in-law *von Hippel* was Director.

Description of German Patent # 386,770 *(Appendix 18 – 1)*
The disadvantages of spectacle glasses are so apparent that it was absolutely of first importance to find an alternative to them by ensuring visual correction by a "*a suitably supplied optical medium between ocular globe and eyelids*". (20) At this time, only shells made from blown glass, described as "vaulted shells", were in use to correct irregularities of the cornea and intended to create a regular anterior corneal surface; these

were the contact shells of *Müller*.

Contact lenses had to have the following assets if they were to be of practical use:

- have a spherical curvature in their corneal zone for the correction of the most common refractive errors,
- not be too expensive,
- be able to be arranged in a graduated sequence in lens trays to facilitate easy use.

The new manufacturing procedure fulfills all of these requirements. Progress resided in the fact that it was no longer glass that was used but *Cellon* (Celluloid), or an organic substance of similar mechanical and optical properties:

"Progress occurs essentially because of the fact that the material chosen is not glass, but Cellon, celluloid, or other organic substances with similar mechanical and optical properties." (21)

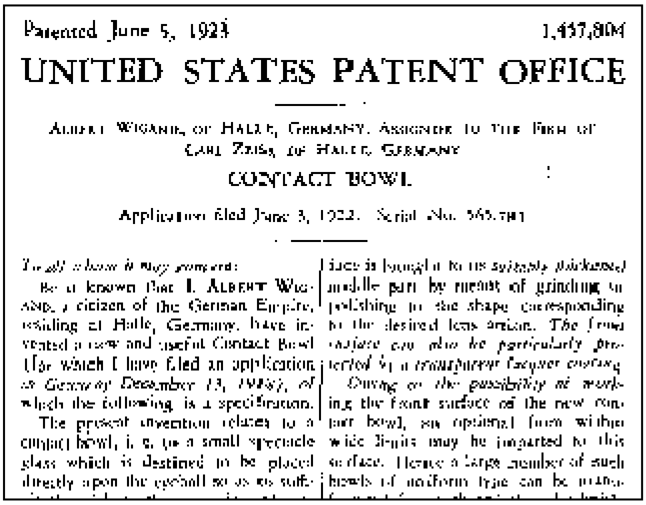
The patent includes all plastic materials, particularly celluloid, the shape of which is obtained by pressure or by molding with heat and which would even be susceptible to being ground or polished:

"The basic material is fashioned by molding or pressure at the temperature appropriate for it to give the shape corresponding to the cut of the front surface of the ocular globe and of approximately 1 mm in thickness. By grinding and polishing, the thicker central portion conforms to the shape of the lens that is being researched. If need be, a thin bed of lacquer can be added there." (21)

The patent foresees numerous advantages: suppleness of the material, resistance to breakage, thinness, and chemical stability to erosion by tears:

"1.) flexibility, good adaptation, and gentle adherence to the eyeball without injuring it,
2.) the spectacle is unbreakable and provides mechanical protection for the eye at the same time (application as protective spectacle);
3.) reduced thickness for the most highly convex portion of the spectacle that is situated in front of the cornea and has the highest curvature, by reason of the high refractive index of the material;
4.) chemical resistance to lacrimal fluid." (21)

The claims of the patent are summarized in two points:



Patented June 5, 1923 1,457,804

UNITED STATES PATENT OFFICE

ALBERT WIGAND, OF HALLE, GERMANY, ASSIGNOR TO THE FIRM OF CARL ZEISS, OF HALLE, GERMANY

CONTACT BOWL

Application filed June 3, 1922. Serial No. [illegible]

To all whom it may concern:

Be it known that I, ALBERT WIGAND, a citizen of the German Empire, residing at Halle, Germany, have invented a new and useful Contact Bowl (for which I have filed an application in Germany December 13, 19[illegible]), of which the following is a specification.

The present invention relates to a contact bowl, i. e., to a small spectacle glass which is destined to be placed directly upon the eyeball so as to suff-

face is brought to its *suitably thickened* middle part by means of grinding or polishing to the shape corresponding to the desired lens action. *The front surface can also be particularly protected by a transparent lacquer coating.*

Owing to the possibility of working the front surface of the new contact bowl, an optimal form within wide limits may be imparted to this surface. Hence a large number of such bowls of uniform type can be manu-

Figure 18-5
American Patent # 1,457,804
On June 5, 1923, Wigand acting for the Firm of Carl Zeiss, endorses a patent entitled "Contact Bowl", for which he registered the application.
(See full text in Appendix 18 - 2)

"1.) a process of manufacture for contact spectacles, characterized by the fact, that Cellon, Celluloid, or similar organic substance derives the shape of a thin shell by molding or pressure, and grinding and polishing turns this shell into the required lens form, so that, as soon as it is placed on the ocular globe, it corrects the optical error of the eye by virtue of the grind of the lens, like a contact spectacle.
2.) a contact lens shell, of Cellon, celluloid, or other organic substances having similar mechanical and optical properties." (21)

Description of American Patent #1,457,804: "Contact Bowl"
(Appendix 18 – 2)

On June 3, 1922, *Wigand*, "assignator" to the firm of *Carl*

Zeiss, registered application for the patent. On June 5, 1923, the patent describing the "***Contact Bowl"*** was granted:

"The present invention relates to a contact bowl, i.e., to a small spectacle glass that is destined to be placed directly upon the eyeball so as to stick to it sufficiently in order to move along with the eye in viewing. […]
According to the invention, a transparent organic substance that is resistant to the lachrymal fluid as, for example, cellon or celluloid is softened by heating, having thereupon imparted to it by molding or pressing the shape of a bowl, having the size of the front surface of the eyeball and of about 1 mm thickness, and ultimately its front surface is brought to its suitable thickened middle part by means of grinding or polishing to the shape corresponding to the desired lens action. The front surface can also be especially protected by a transparent lacquer coating.
Owing to the possibility of working the front surface of the new contact bowl, an optional form within wide limits may be imparted to this surface. Hence, a large number of such bowls of uniform type can be manufactured for stock and then, by finishing the front surface, it is possible to attain in each separate bowl that refractive effect which is requisite for removing the existing defect of the eye (keratoconus, astigmatism of the cornea, myopia, hypermetropia, aphacia).
The new contact bowl possesses a certain amount of flexibility and clings to the eyeball; it therefore sticks well without injuring. Being almost infrangible, it serves directly as a sight-preserving spectacle. On account of the comparatively high refractive index of the respective substances, the curvatures of the middle part acting as a lens become comparatively small; the middle part may therefore become comparatively thin."

The Trials with "Cellon Contact Bowl"

Wigand, who initiated the patent, had entrusted to his father-in-law, professor *von Hippel*, the mandate to carry out the trials with the "Cellon contact bowl". *Von Hippel* was professor of Ophthalmology at the University of Halle. We do not have any detailed account or documentation of these experiments. (22) All that we have available is documentation of the scientific communications that took place at the time. They were recalled at the time that two presentations were made. The first of these was in 1928 and the second in 1930 by two participants in the trials: *von Hippel* and his assistant, *Clausen*.
In 1928, *Clausen* of the *Halle University Eye Clinic*, in a communication comparing the blown lenses of *Müller* with the ground lenses of *Zeiss*, described the experiments he had done with contact lenses made from *Cellon*:

"Clausen, in collaboration with the physicist Professor Wigand, carried out experiments during that era with Cellon shells supplied by Zeiss. The same findings were noted as with the keratoconus contact shells of Zeiss, which provoked a total strangulation of the conjunctiva in the vicinity of the limbus and caused episodes of discomfort and extensive corneal erosions." (23)

In 1930, *von Hippel* also described experiments that he had carried out with *Cellon* contact lenses that his son-in-law *Wigand* had invented in collaboration with *Henker*, then director of *Zeiss*:

"Several years ago, the physicist Wigand, who was at Halle at the time and is now in Hamburg, carried out very extensive research in conjunction with Professor Henker of Jena in relation to adhesion glasses. Instead of glass, he used Cellon for this purpose because he thought that the eye might better tolerate this material. From among several subjects, it was established that they could tolerate the glasses for about 5 hours. Long-term wear was, however, not tolerated due to irritative phenomena." (24)

Clausen, who had participated in the experiments when he was an assistant in Halle, gave the following details:

"I personally participated in the experiments that were described just a moment ago by Professor von Hippel and I can do no more than confirm the facts that he presented. The Cellon shells give excellent optical results. The better the shells were fit to the globe, the worse they were tolerated. Normally, the patients were not able to tolerate the shells on the eye for more than a few hours." (25)

Clausen attributes the intolerance to a too-precise fit that conformed to the shape of the eye too well:

"The less the adhesion glasses fit to the anterior eye surface (and this also applies to Müller shells), the longer they can be kept on the eye." (25)

2 - Discussion

The early ground Zeiss contact lenses

Stock's presentation of the first fitting of *Zeiss* lenses in 1920 does not mention the utilization of trial lenses. It is therefore probable that *Stock* had at his disposal only one isolated lens prototype, which could explain the intolerance observed at the time of his trials on the second patient. *Stock* indicates that his choice of the contact lens was made by estimating the height of the summit of the cone with reference to the limbus.

According to *Stock*, his ground *Zeiss* contact lenses had a scleral zone wide enough for them to be held in position by the eyelids. These lenses thus differed from the ground lenses used for trials in physiological optics and from the lenses that *Weill* described and that did not have any scleral component or, at the most, a minimal collarette. These factors made those lenses intolerable because of contact with corneal and palpebral margin.

Müller Brothers, who were the manufacturers of blown contact shells criticized the roughness and the porousness of the ground material, which features were worsened by the attack of tears and were responsible for the complaints of irritation: *"A glass cornea that is not covered by a glazed surface would quickly become unusable due to the corrosive action of tears." (26).* From the first presentations on ground lenses, *Zeiss* documentation emphasizes the quality and resistance of ground glass contact lenses and the care taken in polishing the surfaces:

"Ground glass shells show the same absence of irritation as blown lenses. Because they are well polished and all the ridges are rounded, the glasses are well tolerated without symptoms for extended periods of time." (27).

Criticism stopped when it became apparent that every contact lens, whether blown or ground, deteriorated when it was exposed to tears. Replacement with an identical lens presented a financial problem only for ground lenses, whereas it was just about impossible for blown lenses.

The first ground contact lens presented by *Stock* did not have any innate corrective effect. The "liquid lens" was responsible for optical correction. This early ground contact lenses were conceived, experimented, and placed on the market for the optical correction of keratoconus. The idea, expressed in 1888 by *Panas*, that the contact lens could cure keratoconus by compressing and reshaping the pathological conus was revisited once by *Erggelet* and by *Stock* in favor of the early *Zeiss* ground contact lenses.

The celluloid Zeiss contact lenses

In fact, celluloid (28) is not the ideal material to use for contact lenses. This is because it has two major disadvantages. The first of these is the suppleness, causing it to mold itself intimately to the ocular globe. The other disadvantage is that it is not chemically inert and its degradation releases camphor derivatives that are toxic to the eye.

Cellon is an organic thermoplastic material derived from cellulose dissolved by camphor using low heat and pressure. When it is warm, it can be molded and keeps its shape once it cools down. It is, however, inflammable. The resulting ocular irritative episodes are probably due to the liberation of camphor from its degradation in contact with tears at body temperature.

The process of manufacture by molding as described in the patents produces a standard uniform spherical shell: "*a large number of such bowls of uniform types can be manufactured for stock and then, by finishing the front surface, it is possible to attain in each separate bowl the requisite refractive effect.*"
It is apparent from correspondence between *Wigand* and *Henker* (29) that this process of mass production following a standard model was adopted for economic reasons, standardized in order to obtain the lowest sale prices. Contact lenses manufactured in this way, following a single and unique model, inevitably had to adapt themselves very closely to the sclera and cornea. That corresponds well with the observations of *Clausen* that shells made from cellon *"were causing total asphyxiation of the conjunctiva in the region of the limbus"*. (30)

3 – Historical Assessments of Ground Contact Lenses of Zeiss

Rare are the historians who dwell on the epoch of the prototypes on ground glass and celluloid contact lenses (31). Some conceal this period or describe an impasse up to 1927 or even 1937 (32). In contrast, others claim that the commercial production of *Zeiss* ground lenses may have started at the begining of the 20th century, especially in the United States: "*Because of the relative ease of reasonably exact replacement and wider availability, these Zeiss lenses were the usual lenses of choice during the first two decades of the twentieth century, particularly in North America*." (33). Another source claimed that Zeiss may have manufactured these lenses on a suggestion from Sulzer:

"The firm of Zeiss, at the suggestion of Sulzer (1892), first turned their attention to ground contact lenses in 1892 and 1911, they turned out a systematized series." (34)

It was also written erroneously that *Stock* was himself affected by keratoconus and that he corrected this with *Zeiss* contact lenses: *"Stock, who had a keratoconus himself, had perfect vision with the Zeiss glasses*" (35)

One finds, generally speaking, a deliberate vagueness about this period of history, which the authors typically describe using ambiguous terms:

"*Glass contact lenses were made by Karl Zeiss Optical Works of Jena and described in 1912 and 1923 as ground and polished. A trial set of lenses with four posterior radii was available. They were apparently not used in large numbers. There were also problems in obtaining a high quality optical surface on these lenses, which also restricted their success". (36)*

Conclusion

The years 1912 to 1920 were marked by the trials of *Zeiss* glass and celluloid prototype contact lenses. During this era, *Zeiss* assigned great importance to the refractive effect of the liquid lens enclosed between the front surface of the cornea and the back surface of the contact lens. The firm did not envision that it would manufacture contact lenses with their own refractive power by grinding such power onto their anterior surfaces. The trials with *Zeiss* contact lenses during this historical period were limited to the correction of keratoconus.

Notes

1 See chapter XV: *Early Blown Contact Lenses*, and chapter XVII: *Three Years of Monopoly for Müller's Contact Shells*.
2 In this chapter, we use often the generic term "contact lens" (ISO 8320: *"Contact lens": a generic term including any lens designed to be worn on the front surface of the eyeball. - A "corneal contact lens" is worn in its entirety on the cornea. - A "scleral contact lens" is worn on the cornea and the sclera*). (See Appendix 10-1).
3 See chapter XII: *August Müller's "Hornhautlinse"*.
4 See chapter XIII: *The Decades after the Invention*.
5 For contact lenses used for scientific purposes, see chapter XVI: *Contact Lenses for Physiological Studies*.
6 *Helmbold* 1913/14 (see chapter XV: *Early Blown Contact Lenses).*
7 *"Die 35 jährige Frau […] trägt seit 1 1/2 Jahren ohne jegliche Beschwerden von Müller (Wiesbaden) geblasene Glasprothesen […]. Geschliffene Glasprothesen sind nicht haltbar."* (*Bielschowsky* 1914, p. 220). Communication of May 3, 1914, to the *"Third meeting of the the Hessen and Hessen-Nassau Ophthalmologists" (3.Versammlung der hessischen und hessen-nassauischen Augenärzte)* held in Marburg.
8 *Weill* 1916, p. 127, see chapter XV *Early Blown Contact Lenses* and Appendix 15-2.
9 *Weill* 1916, p. 128, see Appendix 15-2.
10 See chapter XVI: *Contact Lenses for Physiological Studies*.
11 *"Nach Erörterung der optischen Verhältnisse und der Korrektionsmöglichkeiten des Keratokonus wird ein 16 Jahre alter Oberrealschüler vorgestellt, der seit fast drei Jahren an beidseitigem Keratokonus leidet. Er hat früher sehr gut gesehen. Jetzt kann er den Unterricht an der Tafel nicht mehr folgen. R.S. = Fingerz. in 1 1/4 m. ; L.S. = Fingerz. in 1 m. Mit den gewöhnlichen Brillengläsern ist keine nennenswerte Besserung zu erzielen.*
„Ein von der Firma Karl Zeiss hergestelltes, genau geschliffenes Kontaktglas mit kleinem Skleralteil, korrigiert ihn links auf 5/7. […] Mit der Kombination des Brillenkastens [...] hat er dann volle Sehschärfe links. Das rechte Auge erreicht mit dem Kontaktglas nur 5/7-5/10, da eine zarte Trübung der Hornhautkuppe besteht." (*Erggelet* 1916, p. 624). Presentation February 24, 1916, at the meeting of the *Society for Nature and Medicine in Jena* (Naturwissenschaftlisch-medizinische Gesellschaft zu Jena).
12 *"Das Aufsetzen des zuvor mit etwas physiologischer Kochsalzlösung gefüllten Gläschens auf die Hornhaut hat der Kranke selbst auszuführen gelernt.*
Da das Glas ausgezeichnet den Krümmungen des vorderen Augapfelabschnittes angepasst ist, so haftet das leichte, kaum 1/2 mm dicke Schälchen vermöge der Kapillarität vollständig an der Hornhaut. Es verschiebt sich nicht, fällt nie heraus und folgt jeder Augenbewegung." (*Erggelet*, 1916, p. 624-625).
13 *"Das Kontaktglas, das A.E. Fick 1888 angegeben hat, ist frei von allen diesen Nebenwirkungen, weil es sich mit dem Auge bewegt, wie wenn es eine transplantierte Hornhaut wäre. Eine Aenderung der optischen Wirkung bei den Blickbewegungen gegenüber der in der Primärstellung erzielten Korrektion gibt es nicht, wie auch das Auge sich dreht.*
Man kann also mit Recht sagen, das Kontaktglas ist theoretisch die ideale Brille. Es ist nur zu bedauern, dass sie nicht auch für die gewöhnliche Refraktionsanomalien statt unserer üblichen Brillen angewendet werden kann. Das hat seinen Grund in einem Nachteil, der dem Kontaktglas in der Praxis anhaftet. Nicht jedes Auge verträgt die Berührung mit dem Glase, vor allem nicht auf die Dauer. Daran sind schon einige Versuche bei Keratokonuskranken gescheitert, obwohl optisch gute Erfolge vorlagen."
(...) "Auch der vorgestellte Fall erträgt das Glas nicht dauernd. Er hat es einmal ununterbrochen 48 Stunden getragen. Da waren Schmerzen aufgetreten infolge Epithelläsionen der Hornhaut, die aber ohne weiteres abheilten. In den letzten 6 Monaten trägt er das Glas 2-3 mal wöchentlich einige Stunden lang von 9 Uhr früh bis nachmittags 1 oder 4-5 Uhr und geht damit in die Schule. Auf diese Weise macht es ihm keine Beschwerden. Anfangs bemerkte er für kurze Zeit vermehrte Tränenabsonderung. Nachmittags beim Herausnehmen war aber das Auge regelmässig vollkommen reizfrei.
« Aus einiger Entfernung bemerkt man gar nicht, ob er das Glas trägt oder nicht. Der grosse Vorteil, den die Herstellung nahezu voller Sehschärfe für die Vollendung der Schulbildung des Kranken bedeudet, liegt auf der Hand. Aber abgesehen von seiner Wirkung als Korrektionsmittel hat das Kontaktglas vielleicht auch einen gewissen therapeutischen Wert, gewissenmassen als Stützverband zu Schutze für den weiter deformierenden Druck der Lider tagsüber." (*Erggelet* 1916, p. 625).
14 *Erggelet*, 1930.
15 *Stock*, 1920. Presentation to the 42nd meeting of *German Ophthalmological Society (42. Tagung der Deutschen Ophthalmologischen Gesellschaft*) held in Heidelberg.
16 *Stock* 1920, p. 353, see Appendix 18-3.
17 *Stock* 1920, p. 354, see Appendix 18-3.
18 Archives *Zeiss*, Jena # 2330.
19 The contract provides that *Zeiss* guarantee to *Wigand* compensation of 1000- Marks and a 5% commission on the price of sale under license of contact lenses.
20 *"geeignet beschaffenen optischen Medium zwischen Augapfel und Augenlid."*

21 See the original text in Appendix 18-1.
22 My research in the *Zeiss Archives* in Jena and at the *University Eye Clinic in Halle* have remained fruitless. The *Wigand* memoirs that are preserved by his family do not contain any reference to these experiments.
23 *"Clausen hat seinerzeit mit dem Physiker, Professor Wigand zusammen Versuche mit den von der Firma Zeiss hergestellten Cellonschalen angestellt und dabei ähnliche Beobachtungen machen müssen wie bei den Zeisssche Keratokonuskontaktschalen, die zu einer völligen Abschnürung der Bindehaut in der Nähe des Limbus führen und dann unter Umständen Beschwerden und auch ausgedehnte Kornealerosionen verursachen können."* (*Clausen*, 1929, p. 112). - Communication to the 30th meeting of the *Association of the Ophthalmologists of Central Germany (30. Tagung der Vereinigung mitteldeutscher Augenärzte*) held in Leipzig on December 8 and 9, 1928.
24 *"Vor einer Reihe von Jahren hat der Physiker Wigand, damals in Halle, jetzt in Hamburg, ausgedehnte Untersuchungen über die Frage der Haftgläser in Verbindung mit Prof. Henker, Jena angestellt. Er hat dazu ausser Glas das Zellon benutzt, weil er hoffte, dass dieses vom Auge besser vertragen werden würde. Bei einigen Personen wurde erreicht, dass sie die Gläser ca. 5 Stunden tragen konnten. Ein Dauergebrauch war aber wegen den auftretenden Reizerscheinungen nicht zu erreichen."* (*Hippel* 1930/c p. 200-201), in discussion of presentation *Hartinger* 1930/c at the meeting of the *German Ophthalmological Society (Deutsche Ophthalmologische Gesellschaft)* held in Heidelberg. Similar texts are noted in *Hippel* 1930/a and /b.
25 *"Die von Herrn v. Hippel eben erwähnten Untersuchungen habe ich selbst mit ausgeführt und kann die Mitteilungen des Herrn v. H. nur bestätigen. Mit den Zellonschalen wurden in optischer Hinsicht ausgezeichnete Erfolge erzielt. Je besser diese Schalen dem Bulbus sich anpassten, desto schlechter wurden sie im allgemeinen vertragen. Ueber wenige Stunden hinaus waren die Patienten gewöhnlich nicht in der Lage Schalen auf dem Auge zu behalten." (…) "Je weniger die Haftgläser, und das trifft auch für die Müllerschen Schalen zu, der vorderen Bulbusfläche sich anpassen, desto länger können sie auf dem Auge getragen werden."* (*Clausen* 1930/c p. 201) in discussion of presentation *Hartinger* 1930/c at the meeting of the *German Ophthalmological Society (Deutsche Ophthalmologische Gesellschaft*) held in Heidelberg. Same texts noted in *Clausen* 1930/a and /b.
26 *"Die von keiner Schmelzglasur überzogene Glaskornea würde rasch durch die zersetzende Einwirkung der Tränenflüssigkeit unbrauchbar werde." (Müller* 1920, p. 23).
27*"Inbezug auf Reizlosigkeit sind diese geschliffene Glasschalen den geblasenen gleichzusetzen. Da sie gut poliert und alle Kanten abgerundet sind, werden die Gläser für längere Zeit beschwerdenfrei vertragen."* (Documentation *Zeiss*, 1926).
28 Celluloid had been invented by *Hyat* in 1870, primarily to replace ivory, which was used to make billiard balls. It was the first thermoplastic material. Aside from its inflammability and chemical instability, its production expanded greatly, particularly for the manufacture of photographic film and commonplace small objects.
29 In *Archives Zeiss*, Jena # 2330.
30 *"die zu einer völligen Abschnürung der Bindehaut in der Nähe des Limbus führen."* (*Clausen* 1929).
31 It is necessary to note the merit of *Brachner* (1988), who directed an investigation in regard to *Zeiss.*
32 This is particularly the situation in *Albert*'s case (1996, p. 121).
33 *Rosenthal* 1996, p. 372.
34 *Mackie* in *Duke-Elder* 1970, p. 720. There is no document in the *Zeiss* archives supporting this opinion. *Zeiss* was interested in corrective lenses for glasses only after 1925. *Sulzer* always maintained that his contact lenses were ground in Geneva by *Benzoni* and in Paris by *Benoit-Berthiot.* See chapter XIII: *The Decades after the Invention.*
35 *Sitchevska* 1932, p. 1031. This error is often repeated, especially since it appears in *Dickinson*'s Textbook (1942, p. 132) and in *Obrig*'s Textbook (1946, p. 18).
36 *Mandell* 1988, p. 10-11.

Appendix 1

DEUTSCHES REICH

AUSGEGEBEN
AM 17. DEZEMBER 1923

REICHSPATENTAMT

PATENTSCHRIFT

— № 386770 —

KLASSE 42h GRUPPE 31

(W 51832 IX/42h)

Firma Carl Zeiss in Jena.

Verfahren zur Herstellung von Kontaktbrillen.

Patentiert im Deutschen Reiche vom 14. Dezember 1918 ab.

Die zahlreichen Nachteile der Brille, des Kneifers und des Einglases, selbst bei Verwendung der modernsten Vervollkommnungen, sind so offenkundig, daß die Idee, optische Augenfehler durch Einschaltung eines

ter für Augenheilkunde, Bd. 56, S. 400, 1916; Eperon, ebenda, Bd. 61, S. 460, 1918.

Zur allgemeinen Verwendbarkeit wird von Kontaktbrillen gefordert, daß sie bei sphärischer Krümmung des mittleren Teils vor der

Appendix 18-2

Patented June 5, 1923 1,457,806

UNITED STATES PATENT OFFICE

ALBERT WIGAND, OF HALLE, GERMANY, ASSIGNOR TO THE FIRM OF CARL ZEISS, OF HALLE, GERMANY

CONTACT BOWL

Application filed June 3, 1922. Serial No. 565,781.

To all whom it may concern:

Be it known that I, ALBERT WIGAND, a citizen of the German Empire, residing at Halle, Germany, have invented a new and useful Contact Bowl (for which I have filed an application in Germany December 13, 1918), of which the following is a specification.

The present invention relates to a contact bowl, *i. e. to a small* spectacle glass which is destined to be placed directly upon the eyeball so as to sufficiently stick to the same in order to move along with the eye in viewing. By making such contact bowls, as has hitherto taken place, of thin glass without working them later on, it is generally impossible to attain such a finish of the outer surface as is desirable. To improve the finish of the outer surface by grinding is both difficult and expensive; moreover ground glass is not sufficiently resistive to the chemical action of the (alkaline) lachrymal fluid. Besides such a glass bowl is always easily liable to be smashed.

According to the invention a transparent, organic substance, which is resistive to the *lachrymal fluid as, e. g. cellon or celluloid*, is softened by heating, having thereupon impressed to it by moulding or pressing the shape of a bowl having the size of the front surface of the eyeball and of about 1 mm thickness, and ultimately its front surface is brought to the suitably thickened middle part by means of grinding or polishing to the shape corresponding to the desired lens action. *The front surface can also be particularly protected by a transparent lacquer coating.*

Owing to the possibility of working the front surface of the new contact bowl, an optional form within wide limits may be imparted to this surface. Hence a large number of such bowls of uniform type can be manufactured for stock and then, by finishing the front surface, it is possible to *obtain in each separate* bowl that refractive effect which is requisite for removing the existing defect of the eye (keratoconus, astigmatism of the cornea, myopia, hypermetropia, aphakia).

The new contact bowl possesses a certain amount of flexibility and clings to the eyeball; it therefore sticks well without injuring. Being almost unfrangible, it serves directly as sight-preserving spectacles. On account of the comparatively high refractive index of the respective substances the curvatures of the middle part acting as a lens become comparatively small; the middle part may therefore become comparatively thin.

Fig. 1 of the annexed drawings shows *in a section on an enlarged* scale an example for manufacturing

CONTACT LENSES

for stock the bowls which are to be finished later on according to the particular requirements; Fig. 2 shows in a section on the same scale an example for manufacturing a dispersive, Fig. 3 an example for manufacturing a collective bowl.

In Fig. 1 *a* denotes a press-form and *b* a press-stamp. A layer *c* of cellon softened by heating is brought into the mould and then pressed against the latter so as to receive the form shown in Fig. 1.

Fig. 2 shows a dispersive glass which is made of the glass shown in Fig. 1 by working the middle part according to a spherical surface, the centre M_1 of which is at a greater distance from the inner vortex of the bowl than the centre M_2 of the inner surface. The original form is shown by dotted lines, the projecting margin has been cut off. On its outside the bowl is provided with a lacquer coating *d*.

Fig. 3 shows a collective bowl in which the centre M_1 of the outer surface is nearer the vertex than the centre M_2 of the inner surface.

In the appended claim celluloid as well as cellon are included for the above contact bowls.

I claim:

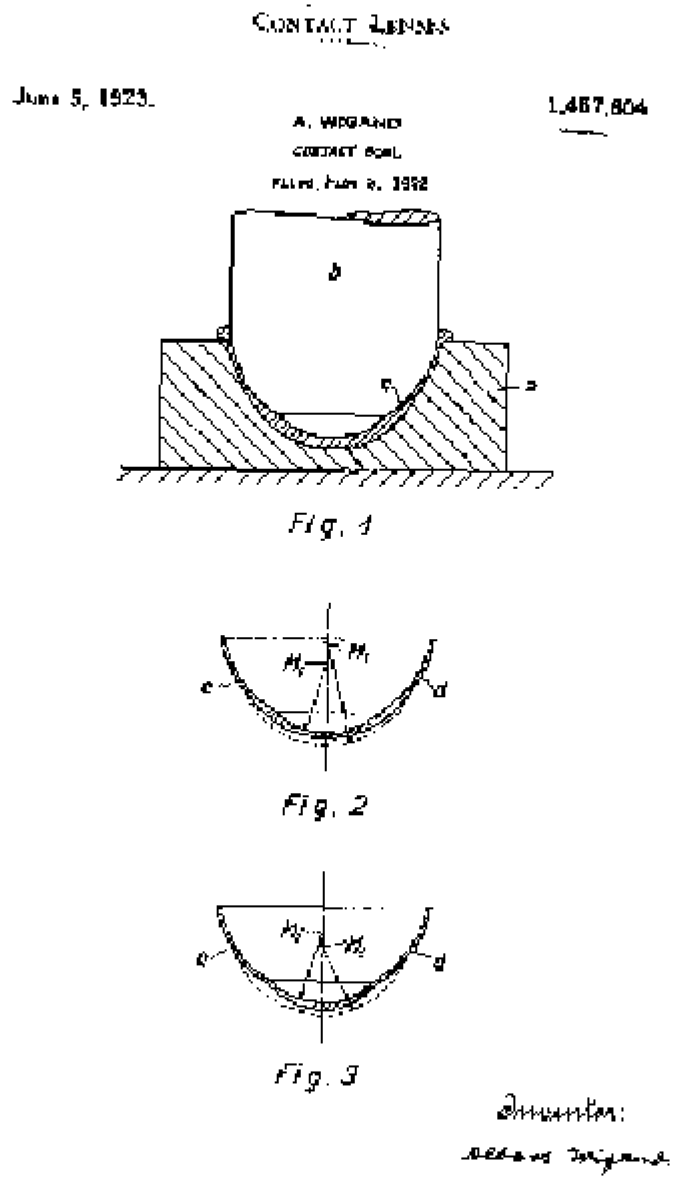
Contact bowl consisting of cellon and being coated on its front surface with a transparent lacquer.

ALBERT WIGAND.

Witnesses:

PAUL KRÜGER.

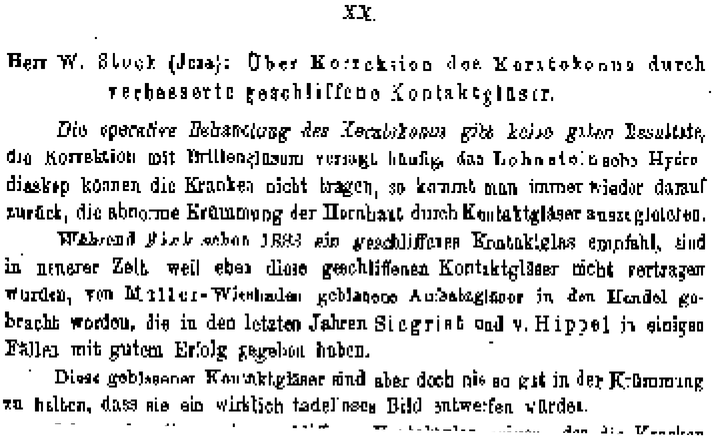
FRITZ LANGE.


June 5, 1923.
Fig. 1
Fig. 2
Fig. 3

Appendix 18 - 3

Excerpt of

W. Stock (Jena)
Über Korrektion des Keratokonus durch verbesserte geschliffene Kontaktgläser
(Bericht der deutschen ophthalmologischen Gesellschaft 1920, 342-354)



XX.

Herr W. Stock (Jena): Über Korrektion des Keratokonus durch verbesserte geschliffene Kontaktgläser.

Die operative Behandlung des Keratokonus gibt keine guten Resultate, die Korrektion mit Brillengläsern versagt häufig, das Lohnsteinsche Hydrodiaskop können die Kranken nicht tragen, so kommt man immer wieder darauf zurück, die abnorme Krümmung der Hornhaut durch Kontaktgläser auszugleichen.

Während Fick schon 1888 ein geschliffenes Kontaktglas empfahl, sind in neuerer Zeit, weil eben diese geschliffenen Kontaktgläser nicht vertragen wurden, von Müller-Wiesbaden geblasene Aufsatzgläser in den Handel gebracht worden, die in den letzten Jahren Siegrist und v. Hippel in einigen Fällen mit gutem Erfolg gegeben haben.

Diese geblasenen Kontaktgläser sind aber doch nie so gut in der Krümmung zu halten, dass sie ein wirklich tadelloses Bild entwerfen würden.

P352

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Diese geblasenen Kontaktgläser sind aber doch nie so gut in der Krümmung zu halten, dass sie ein wirklich tadelloses Bild entwerfen würden.
Ich möchte Ihnen ein geschliffenes Kontaktglas zeigen, das die Kranken vertragen.

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Woran liegt es, dass die geblasenen Gläser besser vertragen werden als die geschliffenen?
Herr Professor Henker und ich haben gerade diese Frage zu lösen versucht.
Müller ist die Ansicht, dass die Oberfläche des geblasenen Glases glatter sei, als die des geschliffenen und dass dieser Unterschied die Ursache der besseren Verträglichkeit des geblasenen sei. Die Oberfläschenbeschaffenheit eines geblasenen Glases ist wohl von der eines geschliffenen etwas verschieden, aber die Hauptschuld, dass die geschliffenen weniger gut vertragen werden als die geblasenen, tragen die scharfen Ränder des geschliffenen. Alle Ränder müssen gut verrunde sein. Nicht nur der äussere Rand, sondern ganz besonders auch der innere Übergang vom skleralen zum kornealen Teil.
Dann ist wichtig, dass die Krümmung des Randteils der Schale der Skleralwölbung genau entspricht, und dass die Hornhaut in der inneren Höhlung Platz findet. Das letztere ist beim Keratokonus nicht immer leicht möglich. Es muss genau abgemessen werden, wie weit die Hornhaut über den Skleralrand vorsteht und darnach waren die Schalen anzufertigen.
Da aber durch diese starke Vorwölbung das Auge – zusammen mit dem Kontaktglase – länger wird, so trat bei gewöhlicher Krümmung das mittleres Skleralteils eine Myopie von ungefähr 12 dpt auf. Ein neu geschliffenes Glas mit 12 dptr geringer Brechung korrigierte den Keratokonus so aus, dass Emmetropie erzielt wurde.
Es ist der Technik (Firma Zeiss) jetzt möglich, die Kontaktgläser in einer solchen Vollkommenheit zu liefern, dass sie den Anforderungen entsprechen:

- Das Kontaktglas besteht aus einem skleralen und einem kornealen Teil. Der sklerale Teil muss so breit sei (ca. 6 mm), dass er auch beim Blick nach oben nicht vom unteren Lidrand gefasst werden kann.
- Sowohl der äussere Rand als ganz besonders der Übergang vom skleralen zum kornealen Teil ist so abgerundet, dass eine Reizung am Auge nicht eintritt.
- Es kann dem kornealen Teil jede beliebige Brechung gegeben werden.

Die Einpassung eines solchen Kontaktglases würde so zu erfolgen haben: Zuerst wird abgemessen, wie weit die Hornhautspitze über den Korneoskleralrand vorsteht. Dann wäre ein Glas anzufertigen, in welches die Hornhaut hineinpasst. Eine noch vorhandene Refraktionsanomalie kann jetzt durch ein Brillenglas, oder besser durch ein neues auskorrigiertes Kontaktglas ausgeglichen werden.
Selbstverständlich könnte sich auch der Augenarzt das eine oder andere Kontaktglas anschaffen. Dieses Kontaktglas wird aufgesetzt, die Refraktion bestimmt und nun das richtige passende Glas bestellt.

In der letzten Zeit habe ich zwei Fälle von Keratokonus so auskorrigiert.

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Die eine Frau trägt das Kontaktglas gerne und fast den ganzen Tag. Das Einsetzen macht ihr kaum Schwierigkeiten. Die Sehschärfe ist von 1/60 auf 5/7 gehoben.
In dem andern Falle macht das Einsetzen Schwierigkeiten, weil immer wieder Luftblasen zwischen Glas und Hornhaut kommen. Sehr merkwürdig ist die Beobachtung der zweiten Patientin dass, nachdem sie das Glas getragen hat, das Sehvermögen besser sei als vorher. Dieselbe Beobachtung hat auch v. Hippel beschrieben. Ob wirklich eine Abflachung des Konus eintritt, konnte ich noch nicht feststellen. Wenn aber diese Gläser auch noch einen therapeutischen Wert hätten, wären sie ja doppelt angezeigt.
Ich möchte nur erwähnen, das ich bei allen Keratokonusfällen selbstverständlich eine Untersuchung des Blutes nach Abderhalden habe ausführen lassen. Die Untersuchung wurde von Kollege Hirsch nach der neuen interphärometrischen Methode ausgeführt. Es wurde dabei festgestellt – ganz wie Siegrist und v. Hippel angegeben haben - , dass einzelne innere Drüsen mit dem Serum Abbau zeigen. Die Zahl meiner untersuchten Fälle (4) ist aber zu klein, als dass ich schon Schlüsse daraus ziehen könnte.